Upper Mantle Anisotropy

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Outline

- What is seismic anisotropy?
- How to measure the anisotropy?
- What is the meaning of measured anisotropy?
- Summaries for our main paper.
Seismic Anisotropy

- The directional dependence of seismic velocity in a medium.
- So it is an elastic property of a medium.
- For example, olivine is a very strong anisotropic mineral.
Seismic Anisotropy

- **Lattice Preferred Orientation (LPO)**
  The main key cause of anisotropy in the crust and mantle.

- **Shape Preferred Orientation (SPO)**
  Geometrical patterns of impedance contrasts, like melt-filled cracks or compositional lamellae.

From: http://garnero.asu.edu/
Where is anisotropy

Where is anisotropy in the Earth?

- crust
- lithosphere
- transition zone
- top of lower mantle
- D''
- inner core

From: http://garnero.asu.edu/
How to Measure the Anisotropy

- **Data:**
  - Shear Wave Splitting
  - Surface Wave
  - Pn wave
  - Receiver Functions

- **Parameters:**
  - *Polarization Direction*
    - Angle between the fast split wave direction and north, clockwise.
  - *Travel Time Difference*

Shear Wave Splitting Measurement

- Using phases passing through the outer core, like: SKS, SKKS, PKS, etc.

  There should be energy on radial component only.

- So we can search for optimal pair of parameters to minimize energy on the transverse comp.

From: Liu, 2009, G cube.
What can anisotropy tell us

- Fast polarization direction reflects the flow direction.

Two Main Papers:

- Toroidal mantle flow throught the western U.S. Slab window

- Vertical mantle flow associated with a lithospheric drip beneath the Great Basin
Toroidal mantle flow through the western U.S. Slab window

Circular pattern of fast split direction and seismic velocity low.
Toroidal mantle flow through the western U.S. Slab window


Fast rollback of Juan de Fuca slab introduce the strong toroidal flow through a slab window
Vertical mantle flow associated with a lithospheric drip beneath the Great Basin
John D. West, Matthew J. Fouch, Jeffrey B. Roth and Linda T. Elkins-Tanton, Nature Geoscience, 2009, doi: 10.1038/NGEO526

- Data
- Shear Wave Splitting
- P-wave tomography
Vertical mantle flow associated with a lithospheric drip beneath the Great Basin


Modeling and Implication